The XMASS experiment

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Recontres de Moriond, Cosmology
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The XMASS experiment

* Multi purpose low-background experiment with LXe
  * Xenon MASSive detector for solar neutrino \((pp/^{7}\text{Be neutrino})\)
  * Xenon neutrino MASS detector (Double beta decay experiment)
  * Xenon detector for Weakly Interacting MASSive Particles (WIMPs DM)
XMASS detector

XMASS is a simple scintillation detector with LXe. (NR and EM)
It is scalable to larger ones because of its simple structure and the long light-absorption length of LXe.

XMASS I (FV: 100kg, Total 1ton)

XMASS II (FV: 10ton, Total 24ton)

The current phase
Funded in 2007
DAQ from 2013

XMASS 1.5
(FV: 1ton, Total 5ton)
Kamioka mine

KamLAND

Super Kamiokande

The XMASS

1,000m overburden

Gigu, JP
The XMASS I history

2010

Installation

2011

Commissioning run

Jan. 2011 ~

~ May 2012

2012

Refurbishment

2013

Run

Nov. 2013 ~

Today

2014

Sep. 2010

Aug. 2013

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Some results from the commissioning rum
Light mass WIMPs search

* Data: 835kg x 6.7 days
* Full volume analysis
* Light Yield: 14.7 P.E./keV
* Threshold: 0.3keV
* (Scaled by 122keV)
* Scintillation efficiency by XENON was used.

\[ \text{Counts/day/kg/keV} \]

\[ \text{Light mass WIMPs search} \]

\[ \text{6.70 days} \times 835 \text{ kg (5591.4 kg-days)} \]

\[ \begin{align*}
18\text{GeV} & \quad \sigma^{\text{SI}} = 1.52 \times 10^{-41}\text{cm}^2 \\
12\text{GeV} & \quad \sigma^{\text{SI}} = 2.84 \times 10^{-41}\text{cm}^2 \\
7\text{GeV} & \quad \sigma^{\text{SI}} = 4.44 \times 10^{-40}\text{cm}^2
\end{align*} \]
Seasonal modulation analysis

- 0.31 ton year (835kg x 136.1 days (LT))
- (Dec. 2010 - May 2012)
- Analysis threshold: $E_{th} = 1\text{keV}_{ee}$
- Only 136.1 day data gives a comparable result as DAMA/LIBRA.

![Graph showing seasonal modulation analysis]
This work
$^{129}\text{Xe}$ inelastic scattering by WIMPs

$\chi + ^{129}\text{Xe} \rightarrow \chi + ^{129}\text{Xe}^*$

$\rightarrow \chi + ^{129}\text{Xe} + \gamma \ (E_\gamma = 40\text{keV}, \tau = 1.0\text{ns})$

Simulated spectrum

N.A. of $^{129}\text{Xe} = 26.4\%$
(1) = pre-selection
(2) = (1) & radius (R < 15 cm)
(3) = (2) & timing cut
(4) = (3) & band cut

165.9 days of data from Dec. 24th, 2010 to May 10th, 2012.

Signal MC for 50 GeV WIMP

Observed spectrum
Inelastic scattering cross section

Asymptotic cross section ($\sigma_{\text{as}}^\text{in}$) [pb]

WIMP mass [GeV]

Red: XMASS 90% U.L. without systematic error
Pink: with systematic error
Black: DAMA LXe 2000 (*)

Now submitting to PTEP

*Axions are produced in the Sun and detected in the XMASS

Bremsstrahlung and Compton effect

Axion travels to the Earth

Axio-electric effect
It is a candidate of the warm DM.

* Mono-energetic peak at the particle-mass (#)
* (#) PRD78, 115012 (2008)

The same analysis can be done for pseudo-scalar bosons

To be submitted.
Refurbishment
**The issues in the commissioning run**

- RIs in Al seal of PMTs
- BG events at blind corners of PMTs are identified as events at the inner side of XMASS.

ATM Data (≈6day data)

- Surface $^{210}$Pb
- PMT Al $^{235}$U-$^{231}$Pa
- PMT Al $^{210}$Pb
- PMT Al $^{232}$Th
- PMT Al $^{238}$U-$^{230}$Th
- PMT (Other parts)
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![Diagram with XMASS refurbishment details](image)
Measures against them

* Cu rings over PMT-Al
  * Minimize scintillation lights from the Al part together with the Al deposition at the side of quartz.
* Thin Cu plates
  * Minimizing the gaps between the PMT rings
    * The gaps are blind corners of PMTs.

[Diagram showing Cu rings and plates around PMTs with Al seals and high purity Al vaporization.]
11 types of the rings

Before ring mounting

After ring mounting
After thin plates installation

Before thin plates installation
A simple parameter, \( \text{maxPE/totalPE} \), is defined.

- The center-region events will give smaller \( \text{maxPE/totalPE} \).
- The events from blind corners will also give smaller \( \text{maxPE/totalPE} \).
* Large BG reduction by the RFB by the quick check
* Now the detailed analysis are on-going.
* DAQ steadily continues with low $E_{th}$ ($\sim 0.3keV_{ee}$) from Nov. 20.
* Results will be presented in near future.
Summary

* Introduction to the XMASS was provided.
* The results from the commissioning were shown.
  * Light mass WIMPs
  * Seasonal analysis for WIMPs search
  * $^{129}$Xe inelastic scattering by WIMPs
  * Bosonic super-WIMPs
  * Solar axion
* Refurbishment of XMASS and the current XMASS status were presented.